SHOCK INTENSITY IN VARIABLE-INTERVAL ESCAPE SCHEDULES[1]

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Time (interval) schedules for response-contingent termination of aversive stimu-li have been used by Keller (4) and by Kaplan (3) with light and by Barry and Harrison (1) with tone. Electric shock is sometimes assumed to be too "disorganizing" or too variable in effect to yield orderly relationships, but seems from our obser-vations to offer considerable promise. Some two thousand odd rat-hours of ex-ploratory work indicate that an experimental control that is in most respects adequate can be obtained, at least on low-mean variable-interval schedules, if proper pre-cautions are taken to prevent unauthorized avoidance of the stimulus (by scrambling of electrode polarities, charging of all cage walls, use of brief pulse durations, and clipping of the back), and if sufficiently long shock-off intervals are used (2 minutes for a 30-second VI schedule). In accord with the analysis advanced by Dinsmoor, Matsuoka, and Winograd (2), this procedure eliminates the tendency for the rat to hold the bar down for long periods of time.

When the level of stimulation is shifted-- and the difference in intensities is large enough to yield a readily discriminable difference in the rates of pressing-- the transition to a new rate is ordinarily immediate, even when the animal is being presented with a new intensity for the first time. The change in rate is usually ap-parent on comparing the first interval of shock after the shift with the last interval before the shift. A rare form of deviation from this pattern is occasionally noted in which the animal continues at a high rate for one or two intervals after the level of current has been lowered, then shifts belatedly but none the less abruptly to the new level. An example of this delayed shift is shown at the arrow in Record A of Fig. 1. In a few cases the initial rate appears to have been set too low, following a large drop in intensity, and may show a gradual upward climb; but these instances are difficult to discriminate from chance variations, and in most cases the rate remains stable following the transition.

We first tried to plot intensity functions by allowing the rate of responding to stabilize for several daily sessions at a given level of current, then taking a new series of readings at a higher or lower level; but this attempt was finally abandoned. Although satisfactory stability was usually found within a single 6-hour session,

unexplained shifts occurred between sessions, sometimes followed by stabilization of the rate at new values. In view of the immediacy of the transitions, we decided that a long test series was not needed, and that a complete set of rates could appropriately be obtained within a single session.

In Fig. 1 we present some cumulative records for responding in the presence of shock. Although each segment represents approximately 1 hour of experimental time, the shock is on only for a mean interval of 30 seconds, which is followed on each occasion by a shock-off interval of 120 seconds. This means that the animal may be in the presence of the shock for only 12 minutes in the hour. If the rate of responding is low, on the other hand, as at 0 or 50 microamperes, relatively few shock-off intervals may be earned and the segment may approach the full hour. To minimize possible disturbances in rate resulting from large shifts in the level of current, we used ascending and descending series, as exemplified by Records B and D of Fig. 1, later comparing the two sets of results for any systematic differences. Each time the level of shock is shifted, as indicated by the cross-hatch, the slope of the record also changes. The abruptness of these changes can better
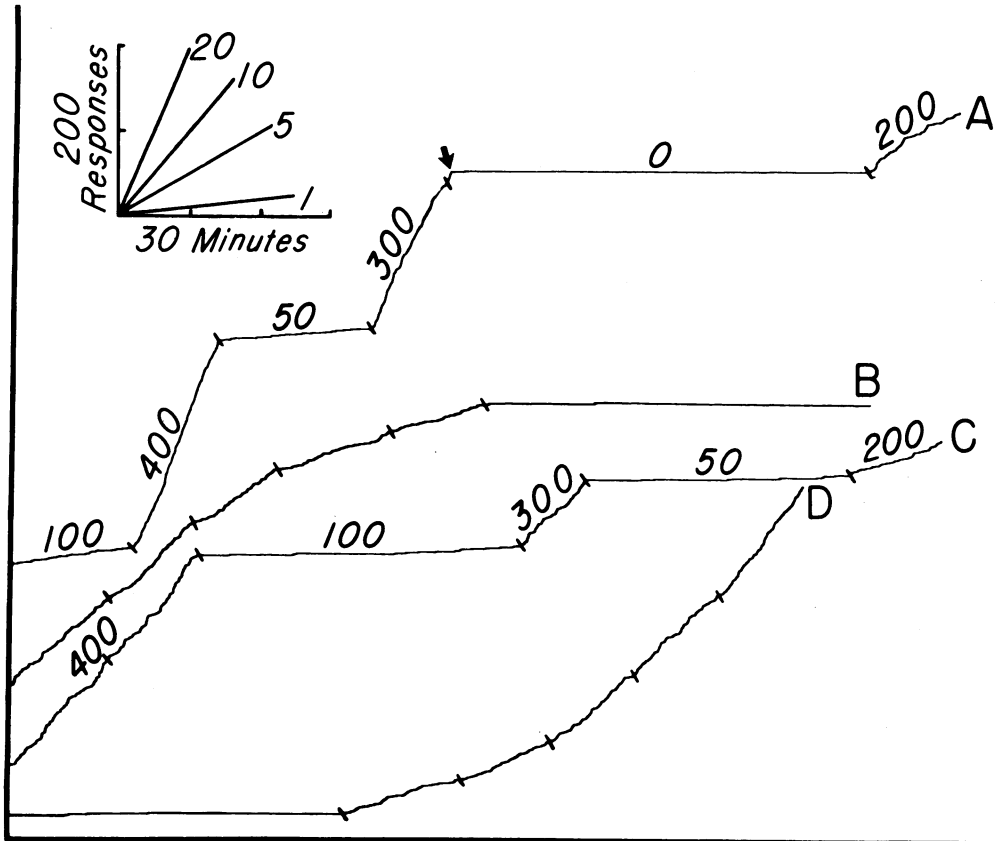

Fig. 1. Four sample records showing immediate changes in rate of pressing with shifts in level of shock current.

be seen, however, where markedly different intensities follow each other in irregular sequence. We therefore had the same animal (also represented in Curves C and D of Fig. 2) draw Record C and another animal (E and F in Fig. 2) draw Record A in order to illustrate these transitions. The numbers represent intensity settings in microamperes. (For milliamperes, divide by 1000.)

The abruptness of these transitions suggests that this function is governed primarily by the discriminative or by the "drive" aspects of the shock rather than by the magnitude of the decrement in stimulation at the point of escape from shock, but the first two factors are not readily separated.

To obtain Fig. 2 we used five albino males, about 8 months old. During the earlier exploratory work, all of them had been given several sessions at most of the levels of current on which they were now tested. The stimulation was a tube-stabilized, half-wave-rectified, unfiltered 60-cycle direct current and flowed in either direction for 0.05-second pulses 78 times per minute. Reinforcement schedules ran from a minimum interval of 7 1/2 seconds in 7 1/2-second steps to an interval equally far above the mean (30 or 60 seconds) of the series; the timing tape stopped only when the shock was turned off. For Records A, B, C, and E we gave our animals a daily "warm-up" hour at 200 microamperes, followed on alternate days by an ascending (0, 50, 100, 200, and 400 microamperes) or a descending series. The
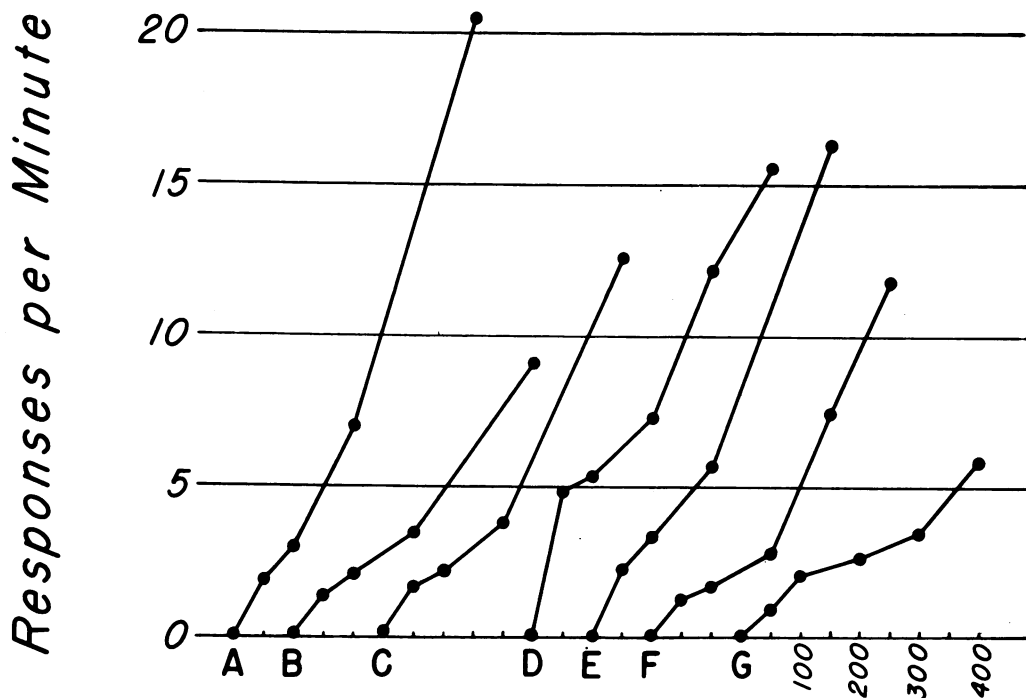

Fig. 2. Seven plots of the relation between level of shock current and rate of pressing on a variable-interval escape schedule.

mean interval was 30 seconds. Since these early records showed a deviation from linearity at 200 microamperes, which we then thought might be related to specific testing conditions, we then dropped the "warm-up" hour and added a 300-micro-ampere setting to the series. Record D is from the same animal as Record C; Record F is from the same animal as Record E, with a 60-second schedule substi-tuted for the original 30-second schedule; and Record G is from a fifth animal, also tested on the 60-second schedule.

Roughly speaking, the rate of pressing is proportional to the level of current. That is, the datum points rarely deviate markedly from a straight line. If, however, the entire array of curves is surveyed, it is evident that the deviations from line-arity are reasonably consistent from animal to animal. From 50 to 400 microam-peres the curve rises with positive acceleration; below 50 microamperes a "break" in this function is strongly suggested, although our present apparatus does not pro-vide for more detailed exploration of this range of values. Correction for oppor-tunities for escape lost because of low rates of response at 0, at 50, and occasionally at 100 microamperes by substituting escapes for minutes as the denominator for the dependent variable does not eliminate this "break" in the function.

Furthermore, this function passes well below the thresholds for sensitivity to shock obtained by previous investigators (5, 6). As a further check on this point, we conditioned three animals de novo at 50 microamperes, using continuous rein-forcement and a 20-second shock-off interval, and transferred them without inci-dent to a VI 30-second (120 seconds off) schedule, on which we maintained them for several 6-hour sessions without ever exposing them to a higher intensity.

SUMMARY

When the intensity of the shock is raised or lowered for rats pressing a bar on a variable-interval escape procedure, the transition to a new rate is usually im-mediate. The rates are roughly proportional to the level of current but show a moderate positive acceleration from 50 to at least 400 microamperes.

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